

(19)



Europäisches Patentamt  
European Patent Office  
Office européen des brevets

(11) Publication number:

**0 045 658**  
**A1**

(12)

**EUROPEAN PATENT APPLICATION**

(21) Application number: **81303556.5**

(51) Int. Cl.<sup>3</sup>: **C 21 C 5/30**

(22) Date of filing: **04.08.81**

(30) Priority: **06.08.80 GB 8025717**

(43) Date of publication of application:  
**10.02.82 Bulletin 82/6**

(84) Designated Contracting States:  
**BE DE NL SE**

(71) Applicant: **British Steel Corporation**  
**33, Grosvenor Place**  
**London SW1X 7JG(GB)**

(72) Inventor: **Collins, Patrick**  
**15 Skottowe Drive Great Ayton**  
**Middlesbrough Cleveland(GB)**

(74) Representative: **Heath, Peter William Murray**  
**British Steel Corporation Patent Section 33 Grosvenor**  
**Place**  
**London SW1 X 7JG(GB)**

(54) **Gas inlet orifice monitoring.**

(57) The invention provides a method of monitoring the operation of a gas inlet orifice below the surface of a liquid under the action of positive gas pressure and with the formation of bubbles at the orifice, comprising the steps of collecting signals indicative of the pressure of the gas flowing through the orifice; removing from such signals the components thereof indicative of the mean pressure of said gas; and monitoring from the remaining components of such signals the pressure fluctuations thereby detected and caused by the formation of gas bubbles at the orifice.

EP 0 045 658 A1

GAS INLET ORIFICE MONITORING

0045658

1        This invention relates to gas inlet orifice monitoring  
and more particularly to a method of and apparatus for  
monitoring or controlling the operation of a gas inlet  
orifice below the surface of a liquid such as molten metal.  
5       in a metallurgical vessel.

      According to the invention there is provided a method  
of monitoring the operation of a gas inlet orifice below the  
surface of a liquid under the action of positive gas pressure  
and with the formation of bubbles at the orifice, comprising  
10      the steps of collecting signals indicative of the pressure  
of the gas flowing through the orifice; removing from such  
signals the components thereof indicative of the mean pressure  
of said gas; and monitoring from the remaining components of  
such signals the pressure fluctuations thereby detected and  
15      caused by the formation of gas bubbles at the orifice.

      The invention is based upon the recognition that except  
in certain unusual and identifiable circumstances gases blown  
into a liquid via an orifice produce bubbles of gas; and that  
such bubble production causes gas pressure fluctuations, which  
20      are usually small but detectable; and that these pressure  
fluctuations constitute a uniquely recognisable "signature"  
of a particular orifice operating under specific conditions,  
which can be monitored for changes brought about by varia-  
tions in gas flow rate, orifice obstruction, and liquid  
25      density changes for example so that operation of that nozzle

1 can likewise be monitored.

In one embodiment the invention includes the steps of connecting the gas flowing through the orifice to a pressure transducer via two separate paths, in one of said paths filtering out pressure fluctuations caused by the formation of gas bubbles at the orifice, mutually opposing said two separate paths at said pressure transducer and monitoring the pressure fluctuations detected thereby.

The filtering in said one path may be achieved by forming that path from pipework having a length and cross-section determined from known criteria to damp and remove fluctuations of the frequency and magnitude which are determined to be related to the relevant bubble formation.

In an alternative embodiment of the invention removal from the signals indicative of the gas flowing through the orifice of the components indicative of the mean pressure may be accomplished by means of an arrangement incorporating a piezo-electric transducer. Thus an electrical circuit, incorporating a filter network to eliminate signals indicative of the mean pressure, may be connected to a piezo-electric interface device. Such an arrangement can have high sensitivity even at high mean gas pressures such as might arise when the orifice is small and/or gas flow rates very high.

25 The method of monitoring provided by the invention is

1 of especial applicability in relation to metallurgical  
process, in particular the production of iron and steel.

Thus in one embodiment of the invention the operation  
of gas supplying tuyeres for metal treatment vessels are  
5 monitored as hereinabove defined. Operation of the  
tuyeres can be controlled in dependence on monitored changes  
in fluctuations, particularly frequency and magnitude changes.

In a typical production plant installation, a system  
of two or more concentric pipes might be used, usually with  
10 an oxidising or exothermic gas passing through an inner pipe  
or annulus and an endothermic gas passing through the outermost  
annulus. Transducers would be fitted in the gas supply lines  
to detect the "signatures". In the case say, of a process in  
steel production in which agitation and stirring of the melt  
15 is carried out by below-melt injection of gases with perhaps  
only two gases involved, such as air and nitrogen, air would  
be supplied to the centre pipe with nitrogen passing through  
the annulus. The pressure "signatures" for the core would  
be obtained with a clear tuyere for a range of flow rates  
20 i.e. datum "signatures". During subsequent operation, the  
tuyere would be operated by adjusting the flow of the coolant  
(nitrogen) to obtain a dynamic thermal and hydrostatic balance  
at the tuyere exit so that a slight build up of metal occurred  
at the exit. This build up should be considered to be a  
25 sacrificial deposit which can be further eroded or built up

1 depending on small thermal inequilibrium. 'The "signatures"  
of the core for this level of build up would also be deter-  
mined and these would be the aim "signatures". In this way  
the aim and minimum level (datum) "signatures" for given  
5 core flow rates are established.

During the normal course of a processing cycle, the  
coolant flow will be adjusted to ensure that the desired  
core "signature" is obtained, e.g. a "signature" denoting  
a reduction in orifice area will initiate a reduction in  
10 coolant flow to restore the signature to the aim. Similarly,  
a move from the aim "signature" towards the datum "signature"  
will initiate an increased coolant flow.

By way of further explanation of this just mentioned  
arrangement it is to be noted that in the commercial opera-  
15 tion of a tuyere the exit dimensions are variable up to the  
limit of the maximum of the pipe dimensions and this exit  
orifice size is controlled by adjusting the proportion of  
exothermic and endothermic fluids. An undue increase in the  
endothermic fluid will result in local overcooling of the  
20 tuyere exit with subsequent chilling of the liquid phase  
above the tuyere on to the tuyere. This growth can continue  
until the tuyere exit dimension is reduced to the extent that  
the tuyere is blocked. The exit size can therefore be con-  
trolled by adjusting the proportions of endothermic and  
25 exothermic fluids to achieve a satisfactory thermal balance

1 in order to produce an orifice with acceptable fluid dynamic  
characteristics. These fluid dynamic characteristics would  
be related to gas dispersion patterns and the preventions of  
liquid ingress into the tuyere.

5 In another embodiment of the invention the method of  
monitoring herein defined can be used to detect the junction  
level between two liquids of different densities. In metal-  
lurgical processes this may comprise the detection of the  
metal/slag interface in vessels.

10 Thus in one application of this embodiment the method  
of monitoring can be used in a blast furnace by detecting  
the level of liquid metal in the hearth and by selecting  
the position of the orifice using this to optimise the slag  
tapping operation. If the orifice is located just below  
15 the slag tapping notch, then when the liquid iron signature  
is detected at that point, slag tapping would commence  
resulting in only a minimum of slag being carried down on  
top of the metal to the lower metal notch. A similar ori-  
fice could be located at the metal notch level to detect  
20 the absence of metal and by inference, prevent tapping any  
slag at all through the notch.

In another application of this embodiment, the method  
of monitoring can be used in a BOS vessel by detecting the  
level of steel above the tap hole entrance to minimise slag  
25 carry over. If the sensor is located beside the tap hole,  
then the gas flow rate can be adjusted so that at some

1 predetermined value, penetration of the gas through the  
liquid steel into the overlying slag without any formation  
of bubbles will be achieved recognised by a total loss of  
"signature", giving time to rotate the vessel before slag  
3 is carried over.

In order that the invention may be more readily understood embodiments thereof will now be described by way of example with reference to the accompanying drawings in which:-

Figure 1 is a schematic view of apparatus for monitoring  
10 the operation of a tuyere;

Figure 2 is a typical "signature" produced by the apparatus of Figure 1; and

Figure 3 is a control diagram for a double tuyere.

Referring to Figure 1 it will be seen that there is  
15 illustrated a tuyere 1 having a consumable end 2 terminating in a nozzle 3 intended for connection into a metallurgical vessel below the molten metal surface therein.

A flush mounting diaphragm pressure transducer 4 is connected into the tuyere 1, the pressure diaphragm being  
20 connected in the tuyere flush to the gas stream at 5. By this means pipework resonance is avoided. The negative pressure tapping of the transducer is connected via low volume filter pipework 6 to the tuyere at 7. The filter pipework was selected by known criteria for filtering the relevant pressure  
25 fluctuations.

1 By connecting the transducer in this manner the operation is independent of overall pressure which is always  
balanced on each side of the pressure diaphragm, only  
signals representative of pressure fluctuations or bubble  
5 "signature" being transmitted.

One result of this is that the risk of damage to the transducer caused by dramatic changes in pressure is greatly reduced.

10 Signals from the transducer 4 are fed to a converter 8 which controls an oscillograph 9 providing a "signature" trace.

A typical "signature" trace is shown in Figure 2 at 10. As will be seen the amplitude of the "signature" is within a range of 100 mbar, when the gas pressure in the tuyere can be up to 7 bar. The time scale of the "signature" is indicated  
15 at 11.

In Figure 3 is shown schematically a possible control arrangement for a tuyere arrangement for metal processing comprising two concentric pipes, the inner or core pipe carrying an exothermic gas and the outer or annular pipe  
20 carrying an endothermic or coolant gas. At optimum operation a slight build up of solid metal at the tuyere nozzle will exist. The desired processing gas flow through the core pipe is measured at 12 and the base "signature" of the core, in particular the frequency of such "signature", at  
25 optimum operation is determined at 13. Thereafter during



operation the "signature", particularly its frequency, is monitored at 14. At 15 dependent on any frequency changes, coolant gas flow to the outer pipe is maintained constant, or reduced if the frequency decreases (indicating an increase in solid metal build up at the tuyere nozzle), or increased if the frequency increases (indicating a decrease in solid metal build up at the tuyere nozzle). By this means positive operational control of the tuyere function is achieved.

The arrangement of Figure 1 can also be regarded as illustrative of an arrangement for monitoring the level of the junction between the liquid metal in the hearth of a blast furnace and the overlying slag layer. In this case, for example, 1 will represent a pipe with an orifice 3 which may be arranged to be located just below the slag tapping notch. As the slag is tapped and the metal level approaches the slag tapping notch, the bubble signal at the orifice 3 will change to indicate the transition from slag to metal and slag tapping can be terminated.

CLAIMS:

1. A method of monitoring the operation of a gas inlet orifice below the surface of a liquid under the action of positive gas pressure and with the formation of bubbles at the orifice, comprising the steps of collecting signals indicative of the pressure of the gas flowing through the orifice; removing from such signals the components thereof indicative of the mean pressure of said gas; and monitoring from the remaining components of such signals the pressure fluctuations thereby detected and caused by the formation of gas bubbles at the orifice.
2. A method according to Claim 1 including the steps of connecting the gas flowing through the orifice to a pressure transducer via two separate paths, in one of said paths filtering out pressure fluctuations caused by the formation of gas bubbles at the orifice, mutually opposing said two separate paths at said pressure transducer and monitoring the pressure fluctuations detected thereby.
3. A method according to Claim 2 wherein the filtering in said one path is achieved by forming that path from pipework having a predetermined length and cross-section such as to remove fluctuations in pressure of frequency and magnitude of the order of the relevant bubble formation.
4. A method according to Claim 1 including the steps of connecting the gas flowing through the orifice to a piezo-

electric transducer, and passing the signal produced thereby through an electrical filter network to eliminate signals indicative of the mean gas pressure.

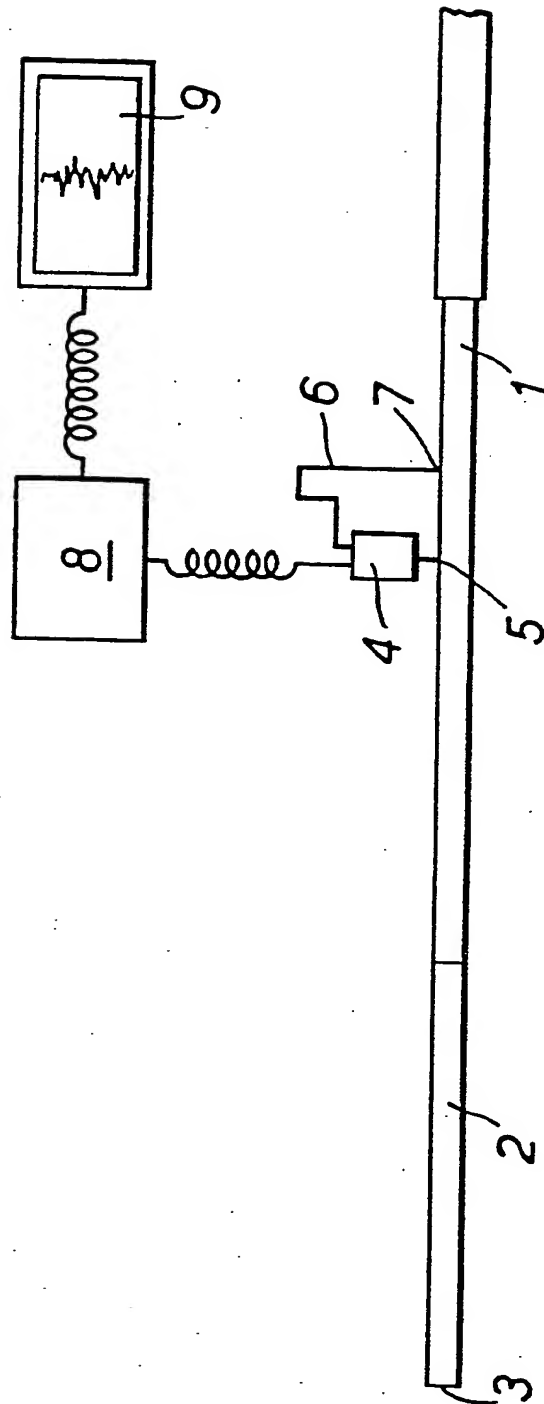
5. A method of monitoring the operation of a gas inlet orifice substantially as hereinbefore described with reference to the accompanying drawings.

6. A method of monitoring the operation of a below-melt tuyere incorporating a method according to any one of the preceding claims.

7. A method of detecting the junction level between two liquids incorporating a method according to any one of Claims 1 to 6.

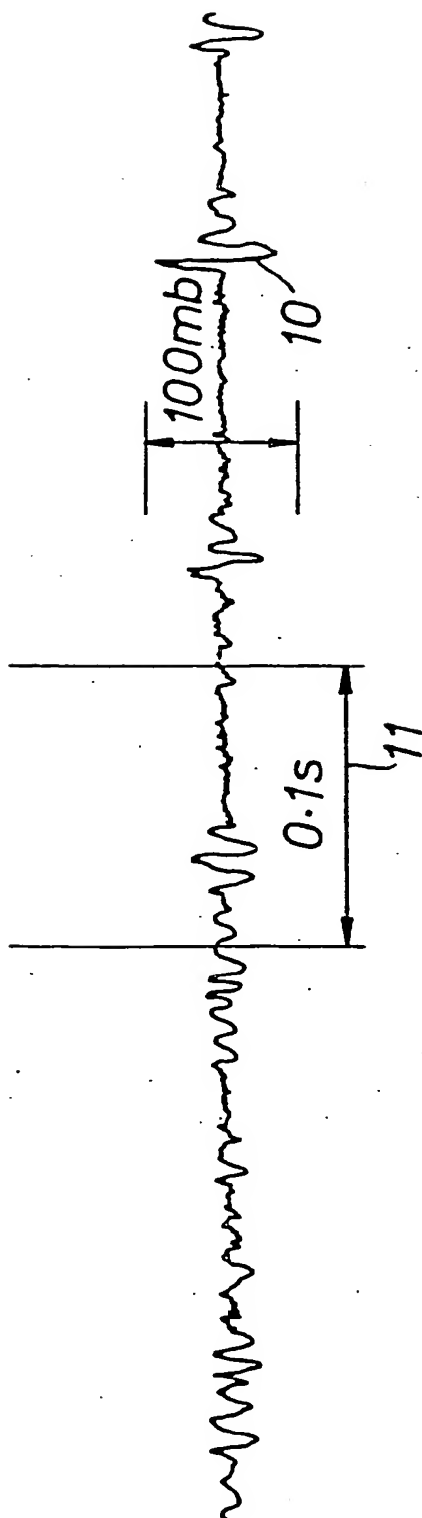
1/3

FIG. 1.

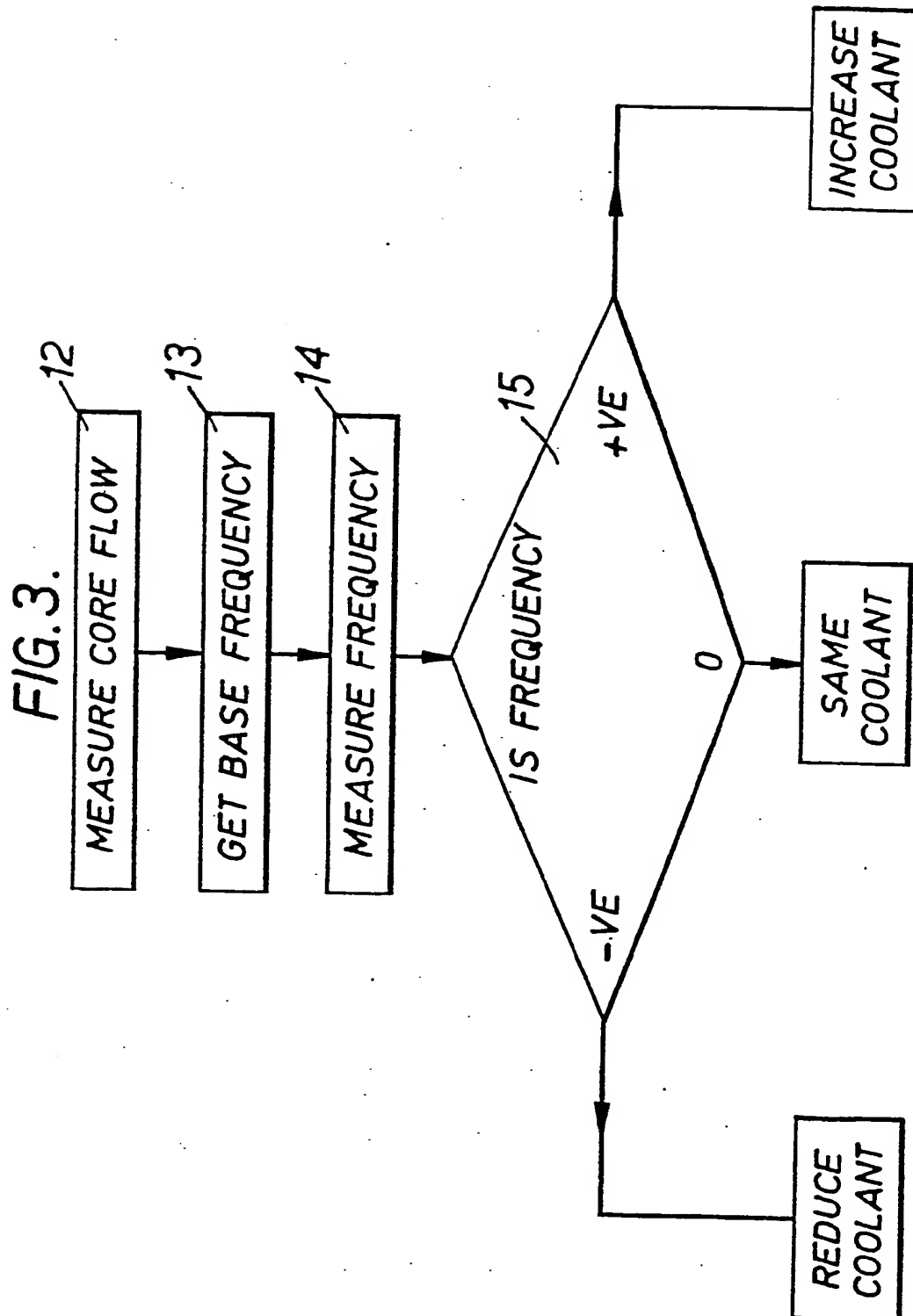


2/3

FIG. 2.



3/3





European Patent  
Office

# EUROPEAN SEARCH REPORT

0045658

Application number

EP 81 30 3556.5

DOCUMENTS CONSIDERED TO BE RELEVANT			CLASSIFICATION OF THE APPLICATION (Int. Cl.3)
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	
	<u>GB - A - 2 003 591</u> (BRITISH STEEL) * pages 2, 3 *	1	C 21 C 5/30
A	<u>GB - A - 1 356 225</u> (ALLEGHENY LUDLUM INDUSTRIES)		
A	<u>GB - A - 1 447 642</u> (USS ENGINEERS AND CONSULTANTS)		
A	<u>GB - A - 1 253 581</u> (EISENWERK - GESELLSCHAFT MAXIMILIANSHÜTTE)		TECHNICAL FIELDS SEARCHED (Int. Cl.3)
A	<u>DE - B2 - 2 326 754</u> (EISENWERK-GESELLSCHAFT MAXIMILIANSHÜTTE)		C 21 C 5/30
A	Patents Abstracts of Japan Vol. 1, No. 132, 31 October 1977, page 5960E77 & JP - A - 52 - 66466		
			CATEGORY OF CITED DOCUMENTS
			X: particularly relevant A: technological background O: non-written disclosure P: intermediate document T: theory or principle underlying the invention E: conflicting application D: document cited in the application L: citation for other reasons
			&: member of the same patent family, corresponding document
<input checked="" type="checkbox"/> The present search report has been drawn up for all claims			
Place of search	Date of completion of the search	Examiner	
Berlin	28-10-1981	SUTOR	

**This Page Blank (uspto)**